DOCUMENT RESUME

ED 053 564 EM 009 147

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TITLE [Forecast Use of Telecommunication Technology in 1985.]
INSTITUTION Stanford Univ., Calif. Inst. for Communication Research.
PUB DATE Sep 71
NOTE 14p.

EDRS PRICE EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS Adult Education, *Cable Television, Communication Satellites, Computer Assisted Instruction, Film Libraries, *Information Networks, Information Retrieval, Innovation, Input Output, Input Output Devices, *Instructional Television, *Interaction, Magnetic Tape Cassettes, Preschool Education, Supplementary Education, *Telecommunication, Television, *Video Cassette Systems

ABSTRACT

Imagine that the year is 1985. The nationwide implementation of telecommunications technology has caused dramatic changes in the use of television in the past 15 years since the 1970's. These changes were initiated when cable television was expanded into the large cities and sets were connected to neighborhood centers which had a channel capacity of up to 200 and large cassette libraries. Two-way instructional television began in 1973 with the use of a simple touch-tone pad connected to a computer at the other end. Then, in 1974, with the implementation of six pilot programs which used large capacity cable television systems in conjunction with the touch-tone pad, coupled with rapid expansion of video cassette players and governmental interest, a system was developed which allowed television sets to be used as computer terminals. By 1980, the telecommunications system was well-developed, and made preschool, supplementary, and continuing education available. Now, in 1985, communication satellites are being used to interconnect three overlapping cable television systems (national, regional, and local), and to provide low cost, 24-hour service to all areas. (SH)

ED053564

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1985

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EM009 147

September, 1971

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Nearly every home, school and office in the country is now obtaining the benefits from a human resources technology initiative begun in the early 1970s. The most dramatic changes that have taken place in the society in the past 15 years can be attributed to the nationwide implementaton of social services, primarily education, making use of the telecommunications technology: cable television, communication satellites, computers and video cassettes.

In these 15 years, the television set has been the focal point of the changes taking place. In 1970 the television set was like the passenger train. It took people to scheduled places at scheduled times. You could look up the schedule to find out what you could see at what time. It provided a window on many different lands, some real and some fantasy. But some lands you couldn't see at all, because the "train" did not run there. Others were only available at infrequent and awkward times. Now, in 1985, the television set is like the personal automobile. Instead of a small number of routes with scheduled times for traveling them, there are a myriad of roads to take and you can 'travel' any one of them at any time to learn whatever you want to learn whenever you want to learn it.

Even in 1970, television was being used for education, some of it very good. Sesame Street, for example. But there was seldom more

than one channel. And for any given person at any given time, it was not really showing what he wanted to learn. Which was not surprising given the fantastic variety of different people with different ages, different interests, different backgrounds and different skills. And with all the different things in the world to learn about, it is no wonder one scheduled channel was not enough. And learning by passively watching the television screen was not as much fun (or as effective) as active participation where you were really doing something interesting.

We knew that having a private teacher was the best way to learn, provided he knew his subject matter and was good at relating to emotional as well as intellectual demands placed on him by his student. But who could afford a private teacher? And besides, those who were good at teaching languages were not always so good at science. And those who were best at responding to emotional needs were not always so good at new math (and vice versa).

So we had instruction in groups, sometimes as many as 40 of us in a group, and often with the teachers changing around so that we took Spanish from the Spanish teacher and math from the math teacher. The better teachers were able to go a long way toward the ideal of the private tutor. They could give us some individual attention, answering questions, providing a kind word or a pat on the back here and there, helping when we were stuck on a problem, and generally understanding how much we already knew so that the next lesson was neither too easy nor too hard. And they made us practice what had to learn so that it was not just a matter of listening to the teacher tell us things. In fact, the really good

teachers kepts us thinking a lot of the time by using what they called the 'Socratic method', asking us a series of questions to force us to think our way through the next steps of the lesson ourselves. We used television some, but usually as a supplement to the regular teaching.

Now, for our children, the television set has become the window into the information utility that permits them to work on any section of any course when it is convenient, just like taking out a particular book from a large library and turning to the third chapter. Except that now they do not have to walk to the library, the book is never checked out to someone else, and they can type in some questions on the television response panel and have the answer displayed on the screen. Often the 'book' asks them questions and then tells them immediately if their answers are correct. It hardly seems like the same television set, now that the keyboard and the video cassette player are added to it and there are computers and satellites somewhere at the other end of the cable. The children still have schools and teachers because there are many things the new communication technology can not do, especially in responding to emotional needs. But the teaching of subject matter competence in most areas and the retrieval of information (if you know what you are looking for) is better done through this new technology.

The transition of the television set from a passenger train to an 'automobile' began back in the early 1970s when cable television began its expansion in the large cities. A that time, the FCC lifted its ban on bringing additional television signals into the 100 largest cities

and required at least 20 channels of television capacity on the cable. Many of our cable television systems today still have that 20 channel capacity, although the more modern ones have expanded to 40 or more channels.

Other systems have been rebuilt so that all the channels do not go directly into every home. Instead, the 'trunk' lines go to neighborhood switching centers. In some cases the 'trunk line' capacity has been expanded to permit up to 200 channels. Since the television set can only be tuned to one channel at a time, a single channel to the switching center from each television set is enough to permit access to all the channels.

In these newer systems, some of the neighborhood centers have video cassette 'juke boxes' with a large library of cassettes including a lot of educational materials. It sure is nice to be able to study anything from beginning chemistry to advanced golf whenever you want, in full living color with the stop action, slow motion and instant replay under your own control. If you want to watch something that is not in the neighborhood cassette library, all you have to do is type in a request on the keyboard that now comes with the television set. They transmit it overnight from the nearest big city library that has a copy and record it at the neighborhood center for showing any time the next day. They say communication satellites are used for the transmission from the big libraries whenever the distance is more than about 35 miles. In the 1970s, NASA experimented with communication satellite systems dedicated for educational uses. That was very exciting and served to convince everybody of the need, once people saw it could be done and how

useful it was. But now they have found that it is cheaper to send educational materials at discount rates on the regular satellites used to interconnect cable systems for entertainment and commercial services.

Many of the cable systems still have just the 20 channel capacity built in the 1970s and many neighborhoods do not yet have the local cassette libraries. Experts are now predicting that we will all have that capability by 1990.

The first regular uses of the two-way cable communication capability came in late 1973. It took nearly two years of research after the hardware was first available to complete the curriculum and program development needed to really effectively use the two-way capability for teaching.

The first effective version of two-way television for teaching used a simple touch-tone pad (like on push-button phones) at each receiver. Wherever possible, the instruction was turned into questions requiring a number as an answer or using multiple choice questions. For example, a version of Sesame Street was modified for two-way television. Children learning to recognize numbers pushed the appropriate number. When they were being taught to count, they pushed a button the appropriate number of times. Graduate engineering courses were also converted to two-way use, with students providing numeric answers to questions or, occasionally, indicating their choice of alternate design in response to multiple choice questions. Throughout the presentation they could push a button to indicate any point at which they disagreed or did not understand.

Responses from up to 10,000 students were collected 40 times per minute. The distribution of responses was displayed at the originating end in case the program needed to be changed (e.g., to substitute a review session for the next five minute segment). The individual responses (identified by student) could be stored so that a computer could analyze the kinds of problems each student was having and mail out a specially selected remedial or supplementary package of instructional materials.

This worked on a single cable system in late 1973. By 1976, multiple cable systems (some of them very small ones in remote hamlets) were linked together through an experimental communications satellite system. Most systems had their own computer at the 'head-end' of the cable, which was also a ground station for the satellite link. Only summary totals of student responses were sent back from such cable systems to the point of origination of the program. Some of the smaller systems transmitted all the student responses directly for compilation on a computer at a larger center.

Satellites were also used in a nine-month demonstration project in 1973 to distribute instructional television directly to schools and to cable television systems throughout the Rocky Mountain region of the United States. But that did not change the kind of instruction much. It distributed one-way instructional television signals to many different places that would not have received it otherwise. It was a big step in the right direction but did not get the recognition it deserved because there were only one or two channels and the quality of the average program

was not as high as that possible for a single national program like Sesame Street. The 1976 experiment with more channels, wider geographic distribution and experimental two-way capability is now recognized as the big turning point in use of satellites for education.

By 1974, pilot two-way cable systems were being installed in 6 different communities across the country. Two were in "new towns", one in Virginia and one in Arkansas. Two older cities, Washington, D. C. and Dayton, Ohio, also had demonstration cable systems. Now, with the hindsight possible from 1985, we can see that the most useful pilot systems were the more research-oriented systems installed in Palo Alto, (near Stanford University) and Boulder, Colorado (near the Telecommunication Research Facility of the Department of Commerce). All six systems had a large capacity, cable television system and the two-way subscriber response capability mentioned earlier.

By 1973, video cassette players were beginning their rapid expansion in the consumer market after a couple of years of slow growth serving primarily institutional markets. Since the cassette players were attached to the television set, we began to get used to using television like a record player with moving pictures. But at $10 per video cassette, most people did not have large collections. There were rental libraries available, but that was not as convenient as having immediate access from your own home. When we wanted to learn something the cassette sure was better than a book or a correspondence course for really explaining how things worked and showing how to do things. You did not even have to be able to read very well to follow the pictures and spoken

words. One of the problems though was that the people who could not read very well could not afford the cassettes and cassette players. So those of us who were already 'information rich' got richer and 'information poor' got relatively poorer. That was part of the reason why the government put all the research and development money into education systems that could provide everyone with access to education.

In 4 of the 6 'demonstration' communities a system was installed that permitted television sets to be used as a computer terminal. There were several different technical ways of accomplishing that goal. One of the simplest was what they called a 'frame-grabber.' It was like a rugged, simplified video tape recorder that recorded only one still picture. The appearance of continuous motion in television pictures comes from the fact that a new 'still' picture is transmitted down the cable (or over the air) 30 times every second, with each new picture replacing the one that went before. Given the speed of electronics, there was plenty of time to send short messages in the time between each new picture every thirtieth of a second. That was used to transmit the 'address' of particular television sets that were to receive the next picture or 'frame', as they called it. The 'frame-grabber' recognized its own address and copied the next picture on the local videotape. Then the television picture was 'refreshed' from the videotape instead of the cable. The touch-tone pad connected with the television set (or, in the more expensive models, an electronic keyboard) was used by the viewer to control what he wanted displayed next. Since each frame had to be displayed a lot longer than one-thirtieth of a second for people to look at or read

the display, a single television channel could be used by at least 300 people (and sometimes twice that many) at the same time. Of course, they got only still pictures, when using the television set this way.

That 'frame-grabber' system permitted a wide range of computer-aided instruction and information retrieval services. By 1975, the pilot projects had demonstrated the technical and economic feasibility of these techniques and by 1977 they were being installed in other cities across the country. It sure made a difference to have completely individualized tutorial instruction available in your own home. For those computer-aided instruction courses requiring audio or motion video responses, instead of just words and still pictures on the television screen, an audio or video cassette was used at the home set, with the computer at the head-end of the system controlling the on and off switch and the positioning of the tape at the home set.

The computer-aided instruction services were in widespread use by 1980, partly because advances in computer technology had brought computer costs down, but also in part because the use of television sets and cable television brought the costs of terminals and communications way down. It helped to share those costs with other services, including entertainment and commercial services available on the same hardware system. It took a large investment in the development of better programs and curriculum techniques, but those were one-time costs.

The early CAI programs in the 1960s were largely 'drill and practice' but the evolution of both CAI and information retrieval techniques converged

into the kind of system permitting a student of law or history to explore widely through a wide range of source documents in the course of his study. Instead of the computer always asking the questions for the student to answer, the student could ask questions of the computer and have relevant documents or portions of documents displayed. That really made the difference in providing computer-aided instruction for adult and continuing education courses.

Most school systems did not have the budgets or the people to conduct the research and development needed to get the telecommunication systems to work effectively. Hardware was not the main problem. But a large amount of curriculum development and program development was needed to make the hardware useful. The 'software' costs were much greater than the hardware and the total costs of systems were larger than their present instructional budgets (primarily in teachers' salaries) in all but the largest school systems. So most school districts just ignored the new technology, except in areas where statewide or multi-state planning took place to spread the utilization far enough to bring the unit costs down to acceptable levels. There had to be a large number of student hours of instruction provided by each course put on video cassette, CAI or two-way television for the cost per student to be sufficiently low. For those school districts that thought of the technology as only providing supplementary services it was hard to justify even the low-costs that resulted with wide use because they were hard pressed to meet their payrolls for teachers' salaries and did not have much money left over for 'extras'.

State legislators, however, began to see the economic benefits to be gained from adding adult and continuing education services by telecommunications instead of continuing to build new community colleges every year. Since the need for 'lifelong learning' was constantly increasing and new community colleges were not able to serve all the people anyway, the new expansion came in telecommunications for continuing education. But that did not happen until after the half-dozen federally supported community demonstration projects showed what could be done.

So the telecommunications system for education developed not primarily for children in the 12 grades of public school, but for preschool, supplementary, and continuing education made available directly to homes and neighborhood day care centers.

Now, in 1985, communication satellites are used to interconnect the cable television systems that provide all these services and to provide direct broadcast to low cost receivers in remote locations. For educational television alone (both one-way and two-way services) there are five television channels of national service in each time zone. Two channels are live direct broadcast on the national network. The other three channels of educational satellite capacity are used to feed special programs on demand to local cable systems, when they have a demand that they cannot fill from their local resources. That way most systems can provide at least 24-hour service for any instructional program that is available anywhere in the country, even if they do not have a copy locally. Those three channels are used for filling real-time requests for digital or still

picture information, with the non-peak channel capacity used to transmit requested motion video in slack time (usually overnight).

The five channels of television bandwidth in each time zone are needed for transmission to the satellite from any of the dozen or so regional centers around the country and thus for transmission to any of the local systems, either within their regions or to other regions.

Approximately one-fifth of that bandwidth is required in the 'reverse' direction. That is primarily for requests from local cable systems to the regional centers or from one regional center to a national center or another regional center. This 'return' communication capability from every local cable system and from individual 'home' receivers in remote areas is also used for the student responses in two-way television and for handling requests for information retrieval and CAI services. Some of the regional centers (especially in Alaska and the Pacific Trust Territories) provide CAI services to home receivers directly by satellite.

In most cases the entire CAI program is transmitted to the computer at the head-end of the cable system requesting it. The particular student then interacts with it through the cable system.

The size of local and regional information banks depends on the number of local and regional requests for information. When there is a request for information, (text or still pictures, but not motion video) that cannot be filled locally the request is transmitted to another regional center in real-time for immediate response. The regional centers are interconnected (via satellite) in a decentralized network

with each one able to 'dial into' each of the other regional centers just as if they were one of its local systems.

The kind and amount of information kept in each local and regional data center was carefully planned on the basis of comparing local storage costs with communication costs involved in retrieving it from elsewhere. National coordination was involved in reaching the administrative agreements guaranteeing that there was a copy of everything of interest in at least two places.

It would be an over-simplification to describe this system as a single hierarchy of local and regional systems with direct broadcast component added. It could better be described as a series of overlapping hierarchies. For example, the medical information system is based on a central service from NIH and regional centers around the country. Each local system interconnects with the nearest regional center, sometimes by cable and sometimes by satellite. The science information system and other specialized services also have their own national and regional sub-systems, all of which can be reached from any television set via the local cable system.

Most of the research needed for the development of this system was in the computer software needed to make it possible on a reliable basis. The satellite was a well-understood technology by the time the cable and computer systems were evolved to the point that interconnection was helpful.